PB-247 344

KILLEN POND, KENT COUNTY, DELAWARE

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center

June 1975

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

PB 247 344

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

☆ GPO—897-033

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Killen Pond, Kent County, Delaware		5. REPORT DATE Prepared June 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper No. 237
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency P.O. Box 15027 Las Vegas, NV 89114		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Eutrophication Survey Branch, Corvallis, OR 97330

16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

PRICES SUBJECT TO CHANGE

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release unlimited	20. SECURITY CLASS (This page)	22. PRICE

41

10

4.00-2.25

EPA Form 2220-1 (9-73)

345049

REPORT ON

KILLEN POND

KENT COUNTY

DELAWARE

EPA REGION III

WORKING PAPER No. 237

WITH THE COOPERATION OF THE

DELAWARE DEPARTMENT OF NATURAL RESOURCES

AND ENVIRONMENTAL CONTROL AND THE

DELAWARE NATIONAL GUARD

JUNE 1975

REPORT ON KILLEN POND

KENT COUNTY, DELAWARE, EPA REGION III

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
National Environmental Research Center
Las Vegas, Nevada

and

Eutrophication Survey Branch
Pacific Northwest Environmental Research Laboratory
National Environmental Research Center
Corvallis, Oregon

Working Paper No. 237

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

June 1975

ib

CONTENTS

	Page
Foreword	ii
List of Delaware Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	3
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	9
V. Literature Reviewed	14
VI. Appendices	15

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin

planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Delaware Department of Natural Resources and Environmental Control for professional involvement and to the Delaware National Guard for conducting the tributary sampling phase of the Survey.

Mr. N. C. Vasuki, Director, Division of Water Pollution Control, Department of Natural Resources and Environmental Control, provided invaluable lake documentation and counsel during the course of the Survey.

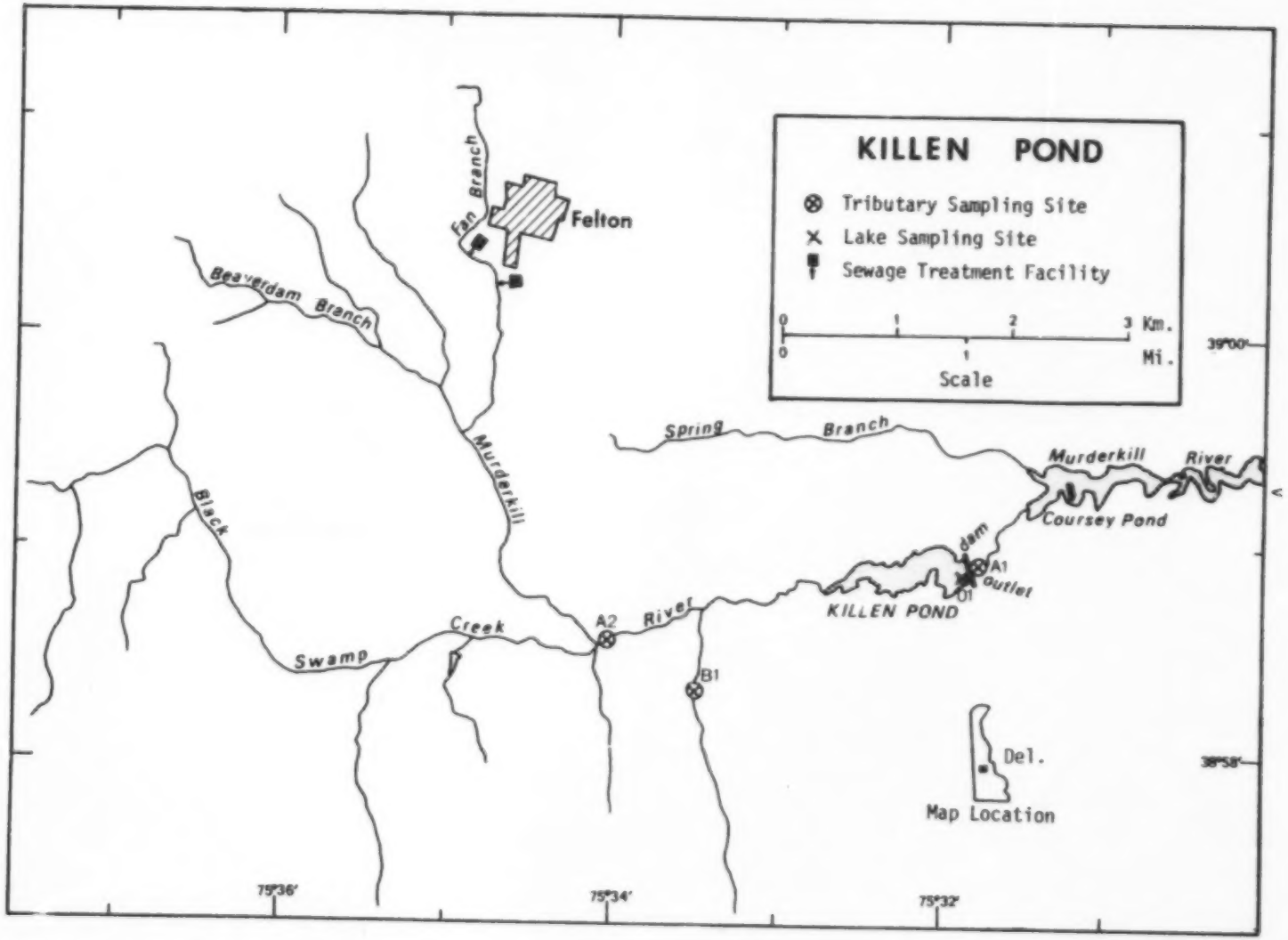
Major General Clarence E. Atkinson, the Adjutant General of Delaware, and Project Officer Colonel Donald S. Robinson, who directed the volunteer efforts of the Delaware National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF DELAWARE

LAKE NAME	COUNTY
Killen Pond	Kent
Moores Lake	Kent
Noxontown Pond	New Castle
Silver Lake	New Castle
Williams Pond	Sussex
Trussum Pond	Sussex


KILLEN POND
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1 2 3 Km.
0 1 Mi.
Scale
Felton
Fan Branch
Beaverdam Branch
Murderkill
Black
Swamp
Creek
Spring
Branch
Murderkill
River
Coursey Pond
dam
A1
Outlet
O1
KILLEN POND
A2
River
B1
Del.
Map Location
39°00'
38°58'
75°36'
75°34'
75°32'

KILLEN POND

STORET NO. 1002

I. CONCLUSIONS

A. Trophic Condition:

Killen Pond is considered eutrophic based upon field observations and analysis of Survey data. Algal blooms were present during summer and fall sampling. Phytoplankton genera identified were generally high pollution-tolerant forms. Chlorophyll a levels were extremely high and Secchi disc visibility was low. Primary productivity as measured by algal assay control yield was high. Unstable water levels and abundant emergent vegetation (spatterdock) have been reported (Ketelle and Uttormark, 1971; Lesser, 1966).

B. Rate-Limiting Nutrient:

Algal assay results indicate that Killen Pond was limited by available phosphorus levels. The ratios of available nitrogen to orthophosphorus in sampled waters indicate phosphorus limitation during spring and summer sampling dates, but nitrogen limitation in the fall.

C. Nutrient Controllability:

1. Point Sources - During the sampling year, the mean annual phosphorus load from point sources was estimated to be 52.2% of the total load reaching Killen Pond. The Swift Co. poultry processing plant contributed 51.9% of the total load. The present loading rate of 14.90 g $P/m^2/yr$ is about nine times that proposed by Vollenweider (in press) as "dangerous" (eutrophic) for a lake of such volume and detention time. However, Vollenweider's model may not apply to water bodies with short hydraulic retention time and the mean hydraulic retention time for Killen Pond is only 8 days.

2. Nonpoint Sources - The mean annual phosphorus load from nonpoint sources was 48.4% of the total load reaching Killen Pond. The Murderkill River contributed 40.5% and the remaining tributaries were estimated to have contributed 7.0%.

Recommendations have been made for the construction of a new water control structure on Killen Pond (Ketelle and Uttormark, 1971; Lesser, 1966). Stabilization of water levels in the lake would curtail the growth of spatterdock. Additional information concerning current land uses is necessary before further recommendations for lake improvements can be made.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area, and mean and maximum depths were provided by the State of Delaware; tributary flow data were provided by the Delaware District Office of the U.S. Geological Survey (USGS)(outlet drainage area includes the lake surface area). Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 0.30 km^2.
2. Mean depth: 1.5 meters.
3. Maximum depth: 2.7 meters.
4. Volume: 0.450×10^6 m^3.
5. Mean hydraulic retention time: 8 days.

B. Tributary and Outlet (see Appendix C for flow data):

1. Tributaries -

Name	Drainage area(km^2)	Mean flow (m^3/sec)
A(2) Murderkill River	36.3	0.53
B(1) Unnamed Tributary	2.8	0.04
Minor tributaries & immediate drainage -	7.0	0.11
Totals	46.1	0.68
2. Outlet - A(1) Murderkill River	46.4	0.68

C. Precipitation:

1. Year of sampling: 117.0 centimeters.

2. Mean annual: 107.4 centimeters.

III. LAKE WATER QUALITY SUMMARY

Killen Pond was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from one station on the lake and from one or more depths at each station (see map, page v). During each visit, depth-integrated samples were collected from the station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first visit, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depth sampled was 1.2 meters at Station 1. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix D and are summarized in III A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III B. Results of the limiting nutrient study are presented in III C.

A. PHYSICAL AND CHEMICAL CHARACTERISTICS:

PARAMETER	(4/10/73) S*** = 1 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(7/20/73) S*** = 1 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(9/28/73) S*** = 1 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)												
0.-1.5 M DEPTH	2	13.0- 13.0	13.0	0.0- 1.2	2	23.8- 27.0	25.4	0.0- 1.2	1	20.2- 20.2	20.2	0.0- 0.0
MAX DEPTH**	1	13.0- 13.0	13.0	1.2- 1.2	1	23.8- 23.8	23.8	1.2- 1.2	1	20.2- 20.2	20.2	0.0- 0.0
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	1	9.2- 9.2	9.2	1.2- 1.2	2	3.0- 13.2	8.1	0.0- 1.2	0	***** *****	*****	***** *****
MAX DEPTH**	1	9.2- 9.2	9.2	1.2- 1.2	1	3.0- 3.0	3.0	1.2- 1.2	0	***** *****	*****	***** *****
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	2	95.- 95.	95.	0.0- 1.2	2	147.- 152.	150.	0.0- 1.2	1	100.- 100.	100.	0.0- 0.0
MAX DEPTH**	1	95.- 95.	95.	1.2- 1.2	1	147.- 147.	147.	1.2- 1.2	1	100.- 100.	100.	0.0- 0.0
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	2	8.3- 8.4	8.3	0.0- 1.2	2	6.7- 10.1	8.4	0.0- 1.2	1	10.3- 10.3	10.3	0.0- 0.0
MAX DEPTH**	1	8.3- 8.3	8.3	1.2- 1.2	1	6.7- 6.7	6.7	1.2- 1.2	1	10.3- 10.3	10.3	0.0- 0.0
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	2	10.- 10.	10.	0.0- 1.2	1	25.- 25.	25.	1.2- 1.2	1	23.- 23.	23.	0.0- 0.0
MAX DEPTH**	1	10.- 10.	10.	1.2- 1.2	1	25.- 25.	25.	1.2- 1.2	1	23.- 23.	23.	0.0- 0.0
TOTAL P (MG/L)												
0.-1.5 M DEPTH	2	0.123-0.124	0.123	0.0- 1.2	1	0.216-0.216	0.216	1.2- 1.2	1	0.300-0.300	0.300	0.0- 0.0
MAX DEPTH**	1	0.124-0.124	0.124	1.2- 1.2	1	0.216-0.216	0.216	1.2- 1.2	1	0.300-0.300	0.300	0.0- 0.0
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	2	0.038-0.038	0.038	0.0- 1.2	1	0.046-0.046	0.046	1.2- 1.2	1	0.070-0.070	0.070	0.0- 0.0
MAX DEPTH**	1	0.038-0.038	0.038	1.2- 1.2	1	0.046-0.046	0.046	1.2- 1.2	1	0.070-0.070	0.070	0.0- 0.0
NO2-NO3 (MG/L)												
0.-1.5 M DEPTH	2	1.400-1.500	1.450	0.0- 1.2	1	1.500-1.500	1.500	1.2- 1.2	1	0.160-0.160	0.160	0.0- 0.0
MAX DEPTH**	1	1.400-1.400	1.400	1.2- 1.2	1	1.500-1.500	1.500	1.2- 1.2	1	0.160-0.160	0.160	0.0- 0.0
AMMONIA (MG/L)												
0.-1.5 M DEPTH	2	0.160-0.160	0.160	0.0- 1.2	1	0.190-0.190	0.190	1.2- 1.2	1	0.080-0.080	0.080	0.0- 0.0
MAX DEPTH**	1	0.160-0.160	0.160	1.2- 1.2	1	0.190-0.190	0.190	1.2- 1.2	1	0.080-0.080	0.080	0.0- 0.0
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	2	0.400-0.900	0.400	0.0- 1.2	1	1.200-1.200	1.200	1.2- 1.2	1	4.400-4.400	4.400	0.0- 0.0
MAX DEPTH**	1	0.900-0.900	0.900	1.2- 1.2	1	1.200-1.200	1.200	1.2- 1.2	1	4.400-4.400	4.400	0.0- 0.0
SECCHI DISC (METERS)	1	0.5- 0.5	0.5		1	0.7- 0.7	0.7		1	0.4- 0.4	0.4	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera		Algal Units per ml
04/10/73	1.	Flagellates	2,278
	2.	Phacus	470
	3.	Cryptomonas	217
	4.	Melosira	181
	5.	Navicula	145
		Other genera	741
		Total	4,032
07/20/73	1.	Microcystis	2,229
	2.	Phormidium	1,501
	3.	Oscillatoria	257
	4.	Blue-green filament	193
	5.	Melosira	86
		Other genera	86
		Total	4,352
09/28/73	1.	Nitzschia	6,395
	2.	Microcystis	5,831
	3.	Scenedesmus	3,386
	4.	Phormidium	2,947
	5.	Cryptomonas	1,066
		Other genera	2,632
		Total	22,257

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll a (micrograms/liter)
04/10/73	1	10.4
07/20/73	1	101.2
09/28/73	1	237.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.052	1.354	15.9
0.05 P	0.102	1.354	28.2
0.05 P + 1.0 N	0.102	2.354	29.4
1.00 N	0.052	2.354	16.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity in Killen Pond was extremely high at the time the sample was collected. The increase in yield with the addition of phosphorus as well as the lack of increase when only nitrogen was added indicates phosphorus limitation. Maximum growth response was achieved with the simultaneous addition of nitrogen and phosphorus.

The ratios of inorganic nitrogen to orthophosphorus in the field samples for spring and summer were 42:1 and 37:1, respectively, indicating phosphorus limitation. The nitrogen to phosphorus ratio for the fall sampling data, however, was only 4:1, indicating nitrogen limitation at that time.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Delaware National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in April 1973 and was completed in March 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Delaware District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of the USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual concentrations in Unnamed Tributary at Station B(1) and mean annual ZZ flow.

The operators of the Felton (Lake Forest High School and Swift Co.) wastewater treatmemt plant provided monthly effluent samples and corresponding flow data.

A. Waste Sources:

1. Known municipal -

Name	Population Served	Treatment	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Lake Forest High School (Felton)	892	Activated Sludge	0.026	Fan Branch/ Murderkill River

2. Known industrial -

Name	Product	Treatment	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Swift Co. (Felton)	Poultry Processing	Activated Sludge	0.791	Fan Branch/ Murderkill River

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A(2) Murderkill River	1,830	40.5
B(1) Unnamed Tributary	160	3.5
b. Minor tributaries & immediate drainage (nonpoint load) -	160	3.5
c. Known municipal STP's -		
Lake Forest High School (Felton)	15	0.3
d. Septic tanks* -	<5	<0.1
e. Known industrial -		
Swift Co. (Felton)	2,345	51.9
f. Direct precipitation** -	5	0.1
Totals	4,515	100.0
2. Output - Murderkill River	2,410	
3. Net annual P accumulation	2,105	

*Estimate based on 1 known lakeside residence.
**Estimated (see NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A(2) Murderkill River	45,960	69.7
B(1) Unnamed Tributary	3,815	5.8
b. Minor tributaries & immediate drainage (nonpoint load) -	3,450	5.2
c. Known municipal STP's -		
Lake Forest High School (Felton)	90	0.1
d. Septic tanks* -	10	< 0.1
e. Known industrial -		
Swift Co. (Felton)	12,320	18.7
f. Direct precipitation** -	325	0.5
Totals	65,970	100.0
2. Output - Murderkill River	62,450	
3. Net annual N accumulation -	3,520	

*Estimate based on 1 known lakeside residence.
**Estimated (see NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
A(2) Murderkill River	50	1,266
B(1) Unnamed Tributary	57	1,362

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible."

	Total Yearly Phosphorus Loading Rate (grams/m^2/year)
Estimated loading rate for Killen Pond	14.90
Vollenweider's "dangerous" or eutrophic rate	1.61
Vollenweider's "permissible" or oligotrophic rate	0.80

V. LITERATURE REVIEWED

Ketelle, Martha J. and Paul D. Uttormark. 1971. "Problem Lakes in the United States." U.S. Environmental Protection Agency Project #16010 EHR. University of Wisconsin, Madison, Wisconsin.

Lesser, Charles A. 1966. "Aquatic Vegetation Survey; Federal Aid in Fish Restoration." Project #F-21-R. Delaware Fish and Game Commission, Dover, Delaware.

U.S. Environmental Protection Agency. 1975. "National Eutrophication Survey Methods 1973-1976." Working Paper No. 175. NERC, Las Vegas, Nevada, and PNERL, Corvallis, Oregon.

Vollenweider, Richard A. (in press). "Input-Output Models." Schweiz. Z. Hydrol.

CONVERSION FACTORS

Hectares x 2.471 = acres

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B

PARAMETRIC RANKINGS OF LAKES

SAMPLED BY NES IN 1973

STATE OF DELAWARE

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1002	KILLEN POND	0.170	1.610	479.333	116.200	12.000	0.042
1005	MOORES LAKE	0.245	2.400	472.667	81.267	4.700	0.071
1007	NOXONTOWN POND	0.160	0.530	478.833	37.600	10.400	0.016
1008	SILVER LAKE	0.227	4.750	465.667	26.700	13.000	0.096
1009	WILLIAMS POND	0.042	2.010	449.333	30.100	8.800	0.010
1010	TRUSSUM POND	0.038	1.280	464.000	5.100	5.800	0.011

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1002	KILLEN POND	40 (2)	60 (3)	0 (0)	0 (0)	20 (1)	40 (2)
1005	MOORES LAKE	0 (0)	20 (1)	40 (2)	20 (1)	100 (5)	20 (1)
1007	NOXONTOWN POND	60 (3)	100 (5)	20 (1)	40 (2)	40 (2)	60 (3)
1008	SILVER LAKE	20 (1)	0 (0)	60 (3)	80 (4)	0 (0)	0 (0)
1009	WILLIAMS POND	80 (4)	40 (2)	100 (5)	60 (3)	60 (3)	100 (5)
1010	TRUSSUM POND	100 (5)	80 (4)	80 (4)	100 (5)	80 (4)	80 (4)

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR DELAWARE 10/20/75

LAKE CODE 1002 KILLEN POND

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 17.90

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1002A1	17.90	29.20	39.90	41.70	35.10	21.60	16.60	14.70	27.80	11.00	12.10	15.30	24.50	24.85
1002A2	14.00	22.90	31.20	32.60	27.50	16.90	13.00	11.50	21.70	8.64	9.50	11.90	19.10	18.81
1002B1	1.10	1.80	2.50	2.60	2.20	1.30	1.00	0.90	1.70	0.70	0.80	0.90	1.50	1.49
1002Z2	2.80	4.50	6.20	6.50	5.40	3.40	2.60	2.30	4.40	1.70	1.80	2.30	3.90	3.75

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 17.90
SUM OF SUB-DRAINAGE AREAS = 17.90

TOTAL FLOW IN = 289.54
TOTAL FLOW OUT = 289.50

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1002A1	4	73	43.60	28	43.00				
	5	73	20.90	20	20.00				
	6	73	14.10	26	11.00				
	7	73	10.10	22	10.00				
	8	73	14.30	18	5.90				
	9	73	7.70	24	6.30				
	10	73	8.50	28	5.80				
	11	73	8.70	11	7.80				
	12	73	28.00	2	5.10				
	1	74	36.40	5	46.00				
	2	74	30.40	9	32.00	28	22.00		
	3	74	34.20	9	18.00	24	37.00		
1002A2	4	73	34.10	28	34.00				
	5	73	16.40	20	15.00				
	6	73	11.00	26	8.20				
	7	73	7.90	22	7.80				
	8	73	11.20	18	4.60				
	9	73	6.00	24	4.90				
	10	73	6.60	28	4.50				
	11	73	6.80	11	6.10				
	12	73	21.80	2	4.00				
	1	74	28.40	5	36.00				
	2	74	23.70	9	25.00	28	18.00		
	3	74	26.70	9	14.00	24	29.00		

TRIBUTARY FLOW INFORMATION FOR DELAWARE 10/20/75

LAKE CODE 1002 ALLEN POND

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
100281	4	73	2.70	28	2.70				
	5	73	1.30	20	1.20				
	6	73	0.90	26	0.60				
	7	73	0.60	22	0.60				
	8	73	0.90	18	0.40				
	9	73	0.50	24	0.40				
	10	73	0.50	28	0.40				
	11	73	0.50	11	0.50				
	12	73	1.70	2	0.30				
	1	74	2.20	5	2.80				
	2	74	1.90	9	1.90	28	1.40		
	3	74	2.10	9	1.10	24	2.30		
100222	4	73	6.80	28	6.80				
	5	73	3.30	20	3.10				
	6	73	2.20	26	1.60				
	7	73	1.60	22	1.60				
	8	73	2.20	18	0.90				
	9	73	1.20	24	1.00				
	10	73	1.40	28	0.90				
	11	73	1.40	11	1.20				
	12	73	4.50	2	0.80				
	1	74	5.80	5	7.40				
	2	74	4.80	9	5.10	28	3.50		
	3	74	5.40	9	3.00	24	5.70		

22.

APPENDIX D

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 75/10/16

100201
38 58 52.0 075 31 50.0
KILLEN POND
10011 DELAWARE

11EPALES
3

2111202
0006 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/10	12 50	0000	13.0		19	95	8.40	10K	0.160	0.900	1.500	0.038
	12 50	0004	13.0	9.2		95	8.30	10K	0.160	0.900	1.400	0.038
73/07/20	09 25	0000	27.0	13.2	26	152	10.10					
	09 25	0004	23.8	3.0		147	6.70	25	0.190	1.200	1.500	0.046
73/09/28	15 30	0000	20.2		17	100	10.30	23	0.080	4.400	0.160	0.070

24.

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/10	12 50	0000	0.123	10.4
	12 50	0004	0.124	
73/07/20	09 25	0000		101.2
	09 25	0004	0.216	
73/09/28	15 30	0000	0.300	237.0

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/10/16

1002A1
38 59 00.0 075 32 00.0
MURDERKILL RIVER
10011 7.5 HARRINGTON
O/KILLEN POND
BRDG AT OR BELO KILLEN POND DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/04/28	08 40		1.740	0.920	0.110	0.042	0.120
73/05/20	08 10		1.840	1.050	0.075	0.058	0.150
73/06/26	15 10		1.520	1.150	0.220	0.077	0.155
73/07/22	08 40		0.270	1.320	0.200	0.050	0.175
73/08/18	09 45		0.273	1.760	0.069	0.094	0.235
73/09/24	09 10		2.020	2.200	0.132	0.008	0.025
73/10/28	09 10		1.900	1.150	0.034	0.006	0.030
73/11/11	09 00		1.440	0.350	0.024	0.009	0.025
73/12/02	10 30		1.760	0.900	0.108	0.084	0.190
74/01/05	10 00		1.510	0.200	0.060	0.008	0.010
74/02/09	10 15		2.600	0.650	0.115	0.050	0.075
74/02/28	10 45		2.500	0.400	0.045	0.010	0.015
74/03/09	10 00		2.000	2.600	0.560	0.180	0.290
74/03/24	08 30		1.510	1.400	0.085	0.055	0.150

26.

STORET RETRIEVAL DATE 75/10/16

1002A2
38 58 30.0 075 34 00.0
MURDERKILL RIVER
10 7.5 HARRINGTON
I/KILLEN POND
US HWY 13 BRDG 3 MI N OF HARRINGTON
11EPALES 2111204
4 0000 FEET DEPTH

27.

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/04/28	08 30		1.260	1.200	0.240	0.066	0.155
73/05/20	08 30		2.100	2.100	0.550	0.169	0.240
73/06/26	15 00		1.900	1.700	0.970	0.420	0.515
73/07/22	08 30		2.120	1.430	0.700	0.140	0.250
73/08/18	09 30		2.000	2.100	1.100	0.510	0.590
73/09/24	09 30		2.300	1.260	0.700	0.310	0.375
73/10/28	09 15		2.200	1.100	0.610	0.270	0.310
73/11/11	09 00		1.520	0.700	0.138	0.075	0.165
73/12/02	10 40		2.200	1.400	0.890	0.280	0.340
74/01/05	09 40		1.600	0.600	0.120	0.048	0.080
74/02/09	09 45		2.600	0.600	0.105	0.055	0.075
74/02/28	11 30		2.520	1.000	0.313	0.085	0.145
74/03/09	09 00		2.000	2.100	0.525	0.180	0.290
74/03/24	09 45		1.900	1.000	0.135	0.075	0.125

STORET RETRIEVAL DATE 75/10/16

100281
38 58 30.0 075 33 30.0
UNNAMED TRIB
10 7.5 HARRINGTON
T/KILLEN POND
BRDG 3 MI N OF HARRINGTON
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/04/28	08 55		1.880	0.710	0.044	0.007	0.015
73/05/20	08 30		2.100	0.520	0.100	0.016	0.020
73/06/26	15 15		1.960	0.480	0.035	0.014	0.025
73/07/22	08 45		1.200	1.680	0.105	0.067	0.165
73/08/18	10 00		2.040	0.270	0.037	0.026	0.035
73/09/24	09 00		0.077	2.730	0.037	0.071	0.270
73/10/28	09 00		1.300	1.[illegible]00	0.044	0.046	0.195
73/11/11	09 00		2.000	0.[illegible]00	0.250	0.168	0.270
73/12/02	10 45		1.700	0.200	0.040	0.008	0.035
74/01/05	09 50		1.600	0.600	0.084	0.048	0.095
74/02/09	10 00		2.460	0.600	0.105	0.050	0.075
74/02/28	11 10		2.300	0.800	0.075	0.040	0.100
74/03/09	09 30		2.000	2.100	0.540	0.185	0.310
74/03/24	09 00		1.500	1.200	0.[illegible]00	0.055	0.150

28

STORET RETRIEVAL DATE 75/10/16

1002AA AS1002AA P000229
39 00 28.0 079 34 15.0
LAKE FOREST HI SCHOOL/FELTON
10011 7.5 WYOMING
T/KILLEN POND
FAN BRANCH/MURDERKILL RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/06	08 00	P							
CP(T)- 73/06/06	15 00		0.620	18.000	3.700	0.830	1.550	0.001	0.001
73/08/08	08 00	P							
CP(T)- 73/08/08	15 00		6.600	5.100	0.070	4.500	6.100	0.001	0.001
73/09/12	08 00	P							
CP(T)- 73/09/12	16 00		4.510	8.400	0.490	2.300	2.600	0.008	0.015
73/10/15	08 00	P							
CP(T)- 73/10/15	14 00		0.780	6.900	0.010K	0.200	0.990	0.009	0.009
73/11/12	08 00	P							
CP(T)- 73/11/12	16 00		1.500	6.300	0.165	0.490	0.650	0.007	0.007
73/12/07	08 00	P							
CP(T)- 73/12/07	14 00		0.400	0.100K	0.040K	0.075	0.095	0.007	0.007
74/01/11	08 00	P							
CP(T)- 74/01/11	14 00		12.600	1.500	0.040K	0.140	0.220	0.007	0.007
74/02/18	08 00	P							
CP(T)- 74/02/18	16 00		0.320	6.800	0.140	0.435	0.760	0.008	0.008
74/03/05	10 00	P							
CP(T)- 74/03/05	15 00		0.040	6.800	0.110	0.490	0.730	0.008	0.008
74/04/11	10 00	P							
CP(T)- 74/04/11	16 00		0.120	9.600	1.150	0.340	0.400	0.008	0.008
74/05/09	08 00	P							
CP(T)- 74/05/09	14 00		0.360	10.000	0.160	6.900	7.700	0.008	0.008
74/06/05	08 00	P							
CP(T)- 74/06/05	14 00		1.480	8.400	0.100	0.250	0.890	0.008	0.008

K VALUE KNOWN TO BE
LESS THAN INDICATED

29.

STORET RETRIEVAL DATE 75/10/16

1002AA AS1002AA P000229
39 00 28.0 079 34 15.0
LAKE FOREST HI SCHOOL/FELTON
10011 7.5 WYOMING
T/KILLEN POND
FAN BRANCH/MURDERKILL RIVER
11EPALES 2141204
4 0000 FEET DEPTH

30.

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/07/06	08 00	P							
CP(T)-			1.680	7.000	0.040	0.280	0.890	0.008	0.008
74/07/06	14 00								

STORET RETRIEVAL DATE 75/10/16

1002AB AS1002AB
39 00 15.0 079 34 40.0
SWIFT CO/FELTON
10 7.5 WYOMING
T/KILLEN POND
FAN BRANCH/MURDERKILL RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/20	08 00	P							
CP(T)-			0.035	110.000	7.100	8.800	21.200	0.122	0.148
73/06/20	12 00								
73/07/25	08 00	P							
CP(T)-			0.090	6.300	0.150	0.850	1.200	0.124	0.110
73/07/25	12 00								
73/08/28	11 00	P							
CP(T)-				23.100	2.100	2.140	2.900	0.245	0.221
73/08/29	10 00								
73/09/19	10 00	P							
CP(T)-			0.072					0.242	0.271
73/09/20	08 00								
73/10/31	08 00	P							
CP(T)-			10.000	1.200	0.016	0.625	0.710	0.222	0.225
73/10/31	12 00								
73/11/28	08 00	P							
CP(T)-			0.110	100.000	7.400	8.300	20.000	0.303	0.230
73/11/29	12 00								
73/12/26	08 00	P							
CP(T)-			9.600	3.800	0.043	0.390	0.600	0.133	0.192
73/12/27	12 00								
74/01/23	08 00	P							
CP(T)-			0.320	11.500	0.080	1.520	2.400	0.203	0.191
74/01/24	24 00								
74/02/20	08 00	P							
CP(T)-			0.360	8.600	0.100	0.990	2.100	0.219	0.200
74/02/21	12 00								
74/03/20	08 00	P							
CP(T)-			0.560	39.000	0.230	1.425	6.375	0.182	0.157
74/03/21	12 00								
74/04/17	08 00	P							
CP(T)-			4.400	30.000	0.450	2.200	6.700	0.208	0.204
74/04/18	12 00								
74/05/29	08 00	P							
CP(T)-			2.080	105.000	1.050	2.100	18.800	0.207	0.244
74/05/30	12 00								

STORET RETRIEVAL DATE 75/10/16

1002AB AS1002AB
39 00 15.0 079 34 40.0
SWIFT CO/FELTON
10 7.5 WYOMING
T/KILLEN POND
FAN BRANCH/MURDERKILL RIVER
11EPALES 2141204
4 0000 FEET DEPTH

32.

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/06/26 CP(T)- 74/06/27	08 00 P 12 00		0.600	29.000	1.550	7.900	10.000	0.381	0.325